CHAPTER 6. FLOODING AND RELATED ENVIRONMENTAL RESOURCE PROBLEMS

PROBLEM IDENTIFICATION PROCESS

Flooding and related environmental resources problems have been identified through discussions with technical support groups. These groups also reviewed the Governor's FEAT Report and past reports prepared by the Corps, DWR, and other Federal and State agencies, including FWS, NMFS, DFG, WCB, and SLC. Problem statements were generated by the group members based on experience and information provided in previous and ongoing programs, plans, studies, and reports (see Appendices A and G for summaries). Specific information describing the flooding problems associated with the 1983, 1986, 1995, and 1997 floods was developed as part of the first phase of the Comprehensive Study; this information is presented in the Post Flood Assessment.

TECHNICAL SUPPORT GROUPS

These groups identified flooding and related environmental resource problems in the Sacramento and San Joaquin River basins. Members of these technical support groups were agency and organization representatives involved in flood management and environmental restoration within the Sacramento and San Joaquin River basins (see Table 6-1).

TABLE 6-1
AGENCIES AND ORGANIZATIONS PARTICIPATING IN THE SACRAMENTO AND SAN JOAQUIN RIVER BASINS TECHNICAL SUPPORT GROUPS

Sacramento River Basin	San Joaquin River Basin
· Department of Water Resources	· Department of Water Resources
· Fish and Wildlife Service	· Fish and Wildlife Service
· Army Corps of Engineers	· Army Corps of Engineers
· University of California, Davis	· University of California, Davis
· Sacramento Area Flood Control Agency	· San Joaquin County
· Sacramento Valley Landowners Assoc.	· San Joaquin River Flood Control Association
· Friends of the River	· The Nature Conservancy
· The Nature Conservancy	· Bureau of Reclamation
· Bureau of Reclamation	· State Lands Commission
· Sacramento River Preservation Trust	
· State Lands Commission	

OTHER ORGANIZATIONS AND INDIVIDUALS

The Study Team also met with several organizations and individuals throughout the Central Valley. These entities were counties, cities, flood control agencies, reclamation districts, levee maintenance districts, landowners association, irrigation districts, the California Central Valley Flood Control Association, and the Natural Resources Defense Council. Discussions among these people further refined the identified problems in the two basins.

SACRAMENTO RIVER
FLOODING AND RELATED ENVIRONMENTAL PROBLEMS

The technical support group for the study of this basin generated descriptions of major flood management and related environmental problems.

FLOODING PROBLEMS

The flood management system in the Sacramento River basin was originally designed to address primarily the effects of flooding on agriculture and to provide for navigation. The design also included the transport of huge amounts of hydraulic mining debris. The mainstem of the river was confined to a narrow corridor between levees to flush the debris through the system, keeping it off the farmlands, and to provide adequate draft for ships. Over the first half of this century, the need for navigation declined significantly, and the system effectively flushed most of the mining debris through. In the second half of the century, the river began to revert to its previous meander-forming condition that entailed erosional and depositional geomorphic processes. It was at this time--around the middle of this century--that the decision was made to undertake erosion control, in the form of the Sacramento River Bank Protection Project, an action that has proven to be a continual, arduous process of counteracting the natural forces of the river. Experience with the flood management system has revealed that geomorphology cannot be controlled. Managing the effects of geomorphology is a more reliable approach. In addition, over the first half of the century, the natural floodplain was converted to agricultural land primarily, and, to some extent, urban development in concentrated areas within the basin. The primarily agricultural activity that grew and benefited from the confinement of the river is now at the greatest risk of being flooded and lost to erosion. At the same time, increasing urban development in the floodplain without a commensurate increase in protection has increased the damage potential.

Although the flood management system on the Sacramento River has prevented billions of dollars in damages and has contributed greatly to the economic development of the State and nation, flood-related problems exist. These problems have been examined and are discussed below.

The Sacramento River Flood Management System may not have the capacity for conveying peak flood flows that it was designed for.

The design of the original Sacramento River flood management system authorized for construction in 1917 was based on two floods in the preceding decade. It is likely that those floods were considered, at that time, to be the largest floods that could reasonably be expected to occur. Conditions have changed since that time, however, and the capacity of the system to handle floods that can now be expected, is less than what was originally planned. In addition, over 80 years of additional knowledge of the system provide a better foundation for planning and design.

Changed conditions that may compromise the capacity include:

- Levee and subsidence along some sections, i.e., near Knights Landing.

- Considerations for sediment transport, erosion, and deposition have changed since the current system was originally designed. The leveed river sections were designed not only to maintain high enough stages for ship navigation, but also to keep flow velocities high enough to transport hydraulic mining debris through the system. The debris is all but gone, but the river still has the same transport capacity, which contributes to erosion of the levee system. The millions of dollars spent on the Sacramento River Bank Protection Project since 1960 demonstrate the effect that continuing erosion has on the system as it is currently configured.

Additional knowledge of the hydrology and hydraulics of the system has been gained and includes:

- The timing of coincident flows throughout the system for recent floods has been different than the events for which the system was designed. The original system was designed to convey the flood waters produced by a composite of two major floods. By 1998, eighty-one years of flood record were available. A review of the flood record (see Post Flood Assessment) indicates that the characteristics of the major floods throughout this time have varied significantly. The locations of the storm centerings, magnitude of the peak flood flows, duration of flows, rates of changes of flows, frequency of flood events, and timing of floods within the year, have been unique for many of the floods or series of floods within a season. This information results in flood conveyance characteristics which diverge from those originally planned.

- ♦ Some channels may not possess their design capacity. For example, under some flood scenarios, the Tisdale Weir and Bypass may not provide design capacity. High stages in the Sutter Bypass sometimes prevent Sacramento River overflows from escaping the leveed river. More water is conveyed down river than designed for, which may impact the level of downstream protection (particularly between Tisdale Weir and Fremont Weir).

- ***The level of flood protection provided by the Sacramento River Flood Management System is not known for many parts of the system.***

There is no model that can evaluate the overall hydraulic performance of the system. It is also likely that the level of protection is not consistent throughout the system, and that the level of protection is not correlated to the value of property/production at risk of flooding.

- ***Some parts of the Sacramento River Flood Management System do not provide reliable flood protection because of structural integrity problems.***

Levee instability and seepage problems, for example, are due to inadequate levee and foundation materials, as well as the construction of drainage ditches on the landside of the levees. Most of the levees were originally constructed by private interests without use of engineering designs and standards. The levee reconstruction projects resulting from the Sacramento River Flood Control System Evaluation do not include work on levees with identified deficiencies in areas which have incremental benefit-cost ratios less than 1.0.

- ***Maintaining the Sacramento River Flood Management System is extremely costly due to the erosive nature of the flood flows that the current system configuration produces and to the impacts to the environment caused by bank protection.***

The tightly leveed system must be continually protected from erosion. The most common material used is rock riprap, which adversely impacts riparian habitat. Mitigation costs have constantly increased.

- ***There is little flexibility in operating the system to optimize flood protection because there is no system model to evaluate operational changes.***

There has been a longstanding need for hydrologic, hydraulic, and ecosystem functions models that assess the entire system. The existing pieces of models should be combined and modified, with deficiencies filled. A major part of Phase I of this Comprehensive Study is to develop such computer models. Phase II will use the models to evaluate system alternatives.

RELATED ENVIRONMENTAL PROBLEMS

The following paragraphs describe the environmental resource problems related to the management of flooding on the Sacramento River.

- ***The natural hydrologic and geomorphic processes that prevailed historically on the middle and lower reaches of the Sacramento River have been largely lost as a result of confining flood flows in reservoirs and between engineered levees.***

The loss of dynamic processes varies by reach of the river; problems increase in magnitude downstream of Chico Landing, and are greatest downstream of Colusa where the levees are set closest together. Seasonal flow patterns have been altered by upstream dams, and by dam release practices which manage river flows and reservoir storage, primarily for flood management and water deliveries. Flows needed to maintain and restore seasonal flooding and to enhance riparian and wetland habitats have often been treated separate from, and sometimes as competing with, flows needed for fish passage, spawning, and rearing.

Seasonal flooding of the floodplain has many benefits to fish and wildlife, such as transport of nutrients, sediments, and woody materials; providing cover, foraging, and breeding habitats for fish and wildlife; regenerating riparian habitat; and groundwater recharge. Upstream dams and bypass systems alter the natural hydrographs by reducing flood peaks, and dampening seasonal flow patterns. Levees and berms isolate historic and potential floodplains from the river ecosystem. These structures also greatly reduce the area subject to relatively frequent, ecologically-significant flooding (versus rare big floods) required for natural establishment, maturation and regeneration of riparian habitats, particularly riparian forests. The reduction in floodplain breadth and habitat conversion has caused a significant reduction in cover for upland species, and has resulted in loss of connection between riparian areas and upland areas available to wildlife as refugia during floods. Areas currently managed for wildlife, such as duck clubs, narrowly focus on management for attracting waterfowl and maintaining access roads, and seasonal flooding patterns have been highly altered from natural cycles.

The natural dynamic process of channel meandering, and meander cutoff, sustains and renews riparian and riverine habitats. In many parts of the river system, dynamic processes are severely compromised by bank protection and channel stabilization, and high-quality natural bank habitat is reduced to a small part of what formerly existed. Channel movement is critical to maintaining a diversity of riparian habitats. Channel cut-offs are important in forming backwater areas such as oxbows, which are valuable to many fish and wildlife, provide areas for riparian succession, and increase the amount of available riparian/aquatic interface. Steep eroding banks are vital to wildlife in that they provide nesting habitat for bank swallows, rough-winged swallows, belted kingfishers, and bank-dwelling beavers, muskrats and invertebrates. Such banks also provide instream woody material used by egrets, herons, river otter, mink, and pond turtles for feeding, resting, and cover. Naturally-eroding banks are also important to aquatic systems and fish. Shaded riverine aquatic (SRA) cover is an important instream cover, and is part of the physical complexity of the channel and shoreline. Bank protection reduces the quality of SRA cover. Food chain dynamics, and habitat for many fish and wildlife species, notably juvenile fish, are also negatively affected.

Historically, large gaps were the exception in the riparian and SRA habitats along the banks of Sacramento Valley rivers and sloughs. Now, gaps are the rule. In reaches with levees, riparian and SRA cover habitats are limited to a narrow, intermittent fringe of habitat, and are separated by large reaches with little or low-quality habitats. Large contiguous blocks of riparian and wetland habitats were once common. Such habitats are rare in the current ecosystem. Loss of linear continuity of riparian habitats can impact the movement of wildlife species among habitat patches, adversely affecting dispersal, migration, emigration and immigration. For many species, the result is reduced wildlife numbers and population viability, both within habitat patches and regionally. Fragmentation of SRA cover results in large gaps where habitat values are minimal. These fragmented habitats impact anadromous and other fishes which migrate long distances within the river system.

- ***As a result of the loss of natural processes, fish and wildlife habitat has been eliminated or severely degraded.***

Riparian forests are among the most biologically rich communities in western North America. In addition to supporting diverse plant and animal communities, riparian vegetation in the Sacramento River system provides an important corridor for movement of wildlife throughout the region. Continuity of the habitat is essential for dispersal, migration, and other movements. Loss of habitat area reduces the numbers of wildlife which can be supported. Fragmentation of remaining habitat decreases its value as a movement corridor, which can lead to a decrease in species diversity within fragments, both by increasing local extinction rates and by excluding from fragments those individuals of species which require large areas of habitat.

An estimated 95 percent of historical riparian areas in the Sacramento River ecosystem has been lost, largely through conversion to agricultural uses, and, to a lesser extent, to urban uses. Wetlands losses have also been large. Levees and upstream dams have enabled the conversion process by reducing flood frequency and intensity. In many cases, land between the levees is also farmed, and where the river continues to meander, depositional areas are converted to agriculture as terrace land becomes available. The net result is loss of riparian habitats, and preclusion of potential riparian habitat establishment where river dynamics persist. Riparian habitats impacted include willow scrub, cottonwood riparian forest, mixed riparian forest, oak riparian forest, and valley oak woodlands. Terrestrial species most seriously impacted include yellow-billed cuckoo, Bell's vireo, Swainson's hawk, willow flycatcher, purple martins, and possibly various mammals, including several bat species.

Spawning and rearing habitat for salmonids and other fish have been lost. Construction of Shasta, Keswick, and other dams blocked access to traditional habitat areas, and has blocked the recruitment of spawning gravels from upstream sources. Lack of suitable spawning gravels is not believed to currently limit salmonid populations in the main Sacramento River, but this shortage could become a problem if populations recover and/or gravel availability decreases further. Channelization and bank protection have reduced the quantity and quality of aquatic habitats used by native fishes for spawning and rearing. Backwater sloughs and oxbows have been cut off from the functional river by levees and land conversion.

Cut banks are an important component of the Sacramento River riparian ecosystem. These river banks sustain the majority of California's colonies of the bank swallow, which is a State-listed endangered or threatened species. Eroding banks also provide nesting habitat for belted kingfishers. Such banks are the sources of sediment and woody material input to the river system. Bank protection has reduced the extent of cut bank habitat.

Fragmentation of habitat has multiple effects upon concerned species. These outcomes include increased edge effects; loss of any species requiring a large block of habitat or highly-localized resources; and effects associated with small, isolated populations. This last consequence engenders increased vulnerability of the species to extinction from environmental, demographic, and genetic impacts.

- ***Mitigation for loss of habitat related to bank protection and to maintaining the Sacramento River flood management system has been inadequate and/or unsuccessful.***

There are several reasons for the problems with mitigation. First, there are funding and procedural constraints on types and amount of mitigation. Avoidance of impacts that require mitigation is preferred, but this could require non-traditional projects, which are difficult to achieve. Assurances to neighboring landowners that infrastructure will not be damaged (perhaps by fixing seepage or drainage problems) by non-traditional projects may be necessary, but can increase the cost. Compensation to owners for the loss of future opportunities on their land may also be needed. The need for conservative designs that assume the worst impacts of mitigation on system integrity and capacity rests within the need to provide for public safety. More information on system capacity, as well as relationships between vegetation and levee integrity, is needed. Often there is a lack of suitable sites to provide habitat comparable to the one impacted, and a lack of suitable methods to provide habitat values comparable to the one impacted (e.g., eroding banks). Preferred lands are frequently unavailable for restoring functional riparian/aquatic systems as mitigation. Downstream of Colusa, for example, restoration is limited by the narrowness of the land strip between levees and the river, and institutional factors often result in siting mitigation areas to lands conveniently available, rather than those most suitable biologically. Mitigation areas tend to be small. Replacement of erodible banks to mitigate for SRA cover impacts of bank protection is usually not possible. A lack of enforcement of revegetating conservation easements purchased on levee berms for mitigation is also a problem.

- ***Restoration of environmental resources (habitats and critical ecosystem processes) has been severely limited.***

Ecosystem restoration is severely hampered by the lack of natural processes (most notably in the Sacramento River downstream of Colusa and in tributaries such as the American River). In addition, Corps and State policies restrict vegetation in rock revetment. Other roadblocks include the threat that restoration could result in restrictions on land use or levee maintenance because of the presence of threatened and/or endangered species. There has been insufficient consideration of non-structural alternatives for flood damage reduction or habitat benefits. An adequate environmental review and mitigation are lacking for project-specific and cumulative impacts. There is no commonly accepted methodology for comparing environmental benefits with the costs of providing those benefits. Integrating environmental resources within the flood management system has not been a feature of past projects.

- ***Invasion by exotic vegetative species threatens the survival of native species and the flow-carrying capacity of the flood management system.***

Invasive non-native plants can competitively displace or, if they become established, exclude native riparian species. Non-native plants typically have low value for wildlife and fish, compared to native riparian vegetation. Problem species include giant reed/false bamboo *(Arundo donax)*, tamarisk (particularly on west-side tributaries), fig, and peppergrass (white top; *Lepidium latifolium*). Levee districts are not adequately informed of appropriate treatments for *Arundo*, and recommendations are needed on controlling this species. Some floodway/levee maintenance practices (frequent disturbance by plowing, herbicide treatment, or burning, and flow management) may even favor exotic species. Some non-natives, such as *Arundo*, can reduce floodway capacity. Conversely, however, these species may have difficulty growing in channels with highly erosive flows (such as the Sacramento River downstream of Colusa).

SAN JOAQUIN RIVER FLOODING AND RELATED ENVIRONMENTAL PROBLEMS

The technical support group for the San Joaquin River basin determined the major problems in flood management and related environmental concerns in the San Joaquin River basin.

FLOODING PROBLEMS

The flood management system on the San Joaquin River has prevented billions of dollars in damages and has contributed greatly to the economic development of the State and nation. Flood-related problems, however, exist. These problems are discussed below.

- ***The San Joaquin River levee and channel system does not have the capacity to convey flood flows as it was designed for.***

The San Joaquin levee system was originally designed to convey rainfall and snowmelt events. However, since the construction of the upstream reservoirs, the primary flood concern in the basin is from rain flood events. In addition, the flow-carrying capacity of the system has steadily diminished. The following factors have contributed to this reduction.

- ♦ Significant sediment load in the San Joaquin system. Channel sedimentation in many locations throughout the system has diminished the overall flow capacity.
- ♦ Localized channel "choke points" of vegetation and/or sedimentation. These flow restrictions lead to a backwater effect of even higher stages upstream of the restriction.
- ♦ Undersizing the downstream limits of the project. The system does not extend far enough into the Delta to adequately pass design flows.
- ♦ Levee alignments in some reaches of the system converge to create "pinch" points. At high flows, these areas restrict capacity and create higher stages.
- ♦ Various bridges in the system restrict flow and cause higher stages.
- ♦ Land subsidence in the basin south of the Merced River has reduced the carrying capacity of the system. This subsidence has increased sedimentation in some reaches and erosion in others.
- ♦ Very low summer flows contribute to the growth of vegetation in the low-flow channels which increase channel deposition and decrease conveyance. Constant (non-varying) flows can also contribute to vegetation growth and decreased channel conveyance.

- ***There is no entity with responsibility to maintain the carrying capacity of the river channel from the Merced River downstream to the Delta.***

Although levee maintenance districts have been established to collectively maintain the many miles of levees in the San Joaquin system, there is no public or private entity that has been tasked with the responsibility of maintaining the flow-carrying capacity of the river channel from the Merced River downstream to the Delta.

- ***Some parts of the levee system do not provide reliable flood protection because of inadequate structural stability, poor foundation conditions, and excessive seepage.***

There were over 20 levee failures in the basin during the 1997 flood. Although some of these failures were caused by levee overtopping, many others were attributable to levee instability and piping failures. In addition, considerable flood fighting resources were expended on numerous boils and excessive seepage along the river. During prolonged high flows, as in 1983 and 1998, seepage causes considerable damage to adjacent agricultural lands and/or delays crop plantings. These problems are likely the result of poor levee foundation conditions and smaller than necessary levee cross section. Geotechnical explorations during Phase II of the Comprehensive Study will help to quantify the extent of these problems and point to potential solutions.

- ***Drainage ditches near the landside levee toe can shorten seepage paths and often contribute to seepage and levee stability problems.***

Drainage ditches near the landside levee toe have been identified in some locations as contributing to a shortened seepage path and slope instability. Relocation of landside ditches has improved the situation at some locations. The idea of relocating landside ditches, in combination with other features, could help the seepage problems in the system and should be examined further.

- ***Optimal use of the flood management system is prevented by the current operation plans for the existing reservoirs and the need for additional storage, in the form of reservoir storage and within the natural floodplain.***

Flood releases in the San Joaquin River system are generally managed to minimize peak flows on the tributary rivers where the project was authorized and not to reduce peak flows along the main stem of the river. This problem is aggravated by the fact that the channel system was not designed to carry the combined peak flow resulting from sustained inflows from the various tributaries.

Based on past performance, and relative to the rest of system, there appears to be reservoir storage deficiencies on the upper watersheds of the San Joaquin and Tuolumne Rivers.

Based on current reservoir operations and on flow-frequency analyses that include the data from 1997, flows from Friant and New Don Pedro both will exceed objective releases between a 25- to 30-year event. The other major reservoirs in the basin are capable of holding to the objective flow at least up to the 50-year event.

For most of the multipurpose reservoirs in the system, opportunities are limited during flood operations to spread the degree of risk between potential loss of water supply and high flood releases. The water supply stakeholders are often not the same parties that will be damaged by higher reservoir releases. They are therefore reluctant to increase flood storage at the expense of conservation storage..

RELATED ENVIRONMENTAL PROBLEMS

Water resources development and related activities in the basin have impacted the environmental resources along the river system. The environmental resource problems related to the flood management are discussed below.

- ***The natural hydrologic and geomorphic processes that prevailed historically along the river system have been largely lost as a result of attenuation of flood flows and confining flood flows between engineered levees and stabilized river channels. As a result of this loss of natural processes, fish and wildlife habitat has been lost or severely degraded.***

The loss of natural processes has greatly contributed to the loss and degradation of fish and wildlife habitat in the system. The loss of dynamic processes varies with reach, but the overall seasonal flow patterns have been altered by the upstream dams, which are primarily managed for water supply and flood management. Because of limited availability of water, the flows needed to maintain and restore seasonal flooding to enhance riparian and wetland habitats have often been treated separate from, and sometimes as competing with, flows needed for fish passage, spawning, and rearing.

The seasonal flooding of floodplains has many benefits to fish and wildlife. These benefits are transport of nutrients, sediments, and woody materials; cover, foraging, and breeding habitats for fish and wildlife; riparian habitat regeneration; and groundwater recharge. Upstream dams and bypass systems altered the system hydrograph by reducing flood peaks, altering seasonal flow patterns, and generally dampening flow hydrographs.

Construction of levees and berms isolate the historic and potential floodplains from the river ecosystem, and greatly reduce the area subject to relatively frequent, ecologically-significant flooding needed for natural establishment, maturation, and regeneration of riparian habitats, particularly riparian forests. The reduced floodplain breadth and habitat conversion has caused reduced cover for upland species, and caused a loss of connection between riparian areas and upland areas available to wildlife as refugia during floods.

Areas currently managed for wildlife, such as duck clubs, narrowly focus on management to attract waterfowl and maintain access roads. As a result, the seasonal flooding patterns have been highly altered from natural cycles.

- ***Fragmentation and insufficient quantity and diversity of remaining riparian, wetland, and shaded riverine habitats is resulting in loss of species numbers and community diversity.***

In the early nineteenth century, over 900,000 acres of riparian forest and woodland existed in the San Joaquin Valley. It is now estimated that the historic extent of riparian habitat has been reduced by about 96 percent. At least half of the remaining riparian vegetation is in disturbed or degraded condition. Although work is underway to reduce losses and restore the condition of existing riparian habitat, the habitat quality and diversity continue to decline.

Fragmentation of riparian habitat in the San Joaquin Valley has severely impacted fish and wildlife populations and the diversity of overall species. Some areas are essentially isolated patches or islands of habitat surrounded by agricultural and urban development. The restriction and isolation of wildlife populations that occurs with fragmentation and geographic isolation of habitat threatens the continued viability of these populations, and in some instances, the species as a whole. If unchanged, the trend for these areas is the continued loss of native species and natural wildlife communities and an increase in non-native species, especially those adapted to degraded and developed areas.

The impacts of habitat fragmentation on wildlife population influence species genetically and demographically. Genetic impacts result from inbreeding depression, which is caused by a population being reduced in numbers and forced into closed, isolated conditions. Fragmentation also exposes individuals to increased mortality by placing them in closer proximity to high risk areas, such as roads and highways, urban development, predators, and exotic species. These conditions have especially high impacts on wide-ranging and migratory species that attempt to move between remnant habitat areas.

The small size of remnant habits in itself has had major consequences for certain species in the San Joaquin Valley. Wide ranging, low density species (usually top level predators) require large parcels of habitat for breeding and feeding. These species do not survive in areas smaller than their minimum home range. Many of the remaining fragments of riparian habitat are simply too small to sustain these species.

The lack of continuity of riparian habitat has eliminated much of the habitat needed to maintain migration corridors for a number of wildlife species. For example, migratory songbirds (warblers, vireos) require continuous habitat to successfully complete their migration route; they have been seriously declining due, in part, to habitat degradation and the effects of fragmentation in North America.

Habitat fragmentation and degradation in the San Joaquin Valley increase the vulnerability of small populations to random, often catastrophic, events such as disease, flooding, other weather-related catastrophes, and fire. The size and isolated nature of populations inhabiting small, remnant riparian areas makes that population extremely vulnerable to such events. Degradation of the remaining areas, including the clearing of woody vegetation, also removes escape areas for wildlife and reduces their chance for survival. In the case of some threatened or endangered species, a single catastrophic event can result in extinction of the species. Small populations are also subject to more intensive predation, competition, and interference from species that can tolerate high disturbance and surrounding habitats.

The major threats to riparian habit in the San Joaquin Valley include: conversion to agriculture; residential, industrial, or recreation uses; flood management operations; new water storage; irrigation diversion and detention facilities; invasion by exotic plant and animal species; livestock grazing; and harvest of mature trees for timber and fuel.

- ***Given the existing levee cross section, restoration of environmental resources along most levee reaches has been limited, in part, by the maintenance policies regarding vegetation on waterside slopes.***

The vegetation found along the waterside and landside slopes of the San Joaquin River provides valuable habitat in the form of SRA Cover, riparian habitat, and grasslands for a variety of fish and wildlife species. SRA cover provides shelter for fish and other aquatic organisms, and consists of a variety of microhabitats, with various flows, depths, shade, cover and food production. Riparian forest canopy, like that found in some areas along the San Joaquin River, provides feeding, breeding, and cover for a variety of Federal- and State-listed and migratory bird species. Grasslands, in the form of berms, sustains several varieties of grasses, forbs, weeds, and woody species which provide valuable habitat for small mammals such as rabbits, ground squirrels, and mice, which in turn provide a food base for larger animals, such as raptors.

Vegetation on some levees has lead to an increased potential for seepage paths and windthrow. This vegetation has attracted burrowing animals that can jeopardize levee integrity, and can, in some cases, increase channel roughness, which in turn causes reduced conveyance and channel capacity. The vegetation also hinders the accessibility for inspection and flood fighting.

In the course of complying with various Federal and State levee maintenance requirements, many local maintenance districts resort to intensive burning and/or cutting of vegetation along levee slopes to prevent growth. These practices improve accessibility and reduce the potential for structural failures, but habitat is lost. Maintenance burning at times has gotten out of control and spread, permanently damaging riparian forest vegetation, including trees nested in by the threatened Swainson's hawk, and elderberry shrub vegetation, which is home to the threatened valley elderberry longhorn beetle.

Some exceptions to existing levee/vegetation policies currently allow for certain trees to be planted on the waterside slope of levees that have been overbuilt to a sufficient depth to preclude root penetration of the root-free zone. In addition, the vegetation must not interfere with the embankment drainage system, and the density of plantings on the structure can not inhibit inspection. Areas where the levee section meets these criteria are limited, but such plantings may be used in system modifications.

- ***Invasion by exotic and annual vegetative species threatens the survival of native species and the flow-carrying capacity of the flood management system.***

The invasion of exotic and annual plants is a growing problem in the region. Invasive non-native plant species can competitively displace and, once they become established, exclude native riparian species. These non-native plants typically have low value for fish and wildlife species compared to the native riparian species. Some non-native species, such as giant reed/false bamboo (*Arundo donax*), can dramatically reduce floodway capacity. Eurasion milfoil and parrotfeather (*Myriophyllum aquaticum*) can cause serious fish and wildlife habitat problems in ponds, streams, and other waterways by blocking out sunlight, altering water temperatures, slowing water flows, and reducing oxygen concentrations in the water.

Many levee districts are not adequately informed of the proper treatment and handling of exotic species such as *Arundo*, tamarisk, fig, and peppergrass (*Lepidium latifolium*). Flood channel and levee maintenance practices, including frequent disturbance by plowing, herbicide treatment, burning, and flow management, may favor the spread and growth of the exotic species.

- ***In a number of places in the system, the river has captured deep pit gravel quarries located close to the existing river channel. These pit captures have caused significant river channel downcutting, have resulted in disrupting the run-riffle-pool sequence, and have created deep lakes within the river system.***

Instream gravel mining entails the removal of streambed sediments by heavy equipment, usually conducted during low water, creating a deep local depression in bed profile. During high flows, the embankment that separates the deep pit from the river can be breached; bed material transported from upstream is deposited in the pit, depriving downstream reaches of bedload sediment and potentially inducing incision downstream of the gravel mine. In addition, head-cutting typically occurs on the upstream of the pit, migrating upstream.

This type of aggregate mining has left deep in-channel pits which occupy half of the spawning reach in the lower Tuolumne River and in a number of other locations within the San Joaquin River basin. These pits are wider and deeper than the natural channel. They are characterized by warm, slow-moving, water-producing conditions more typical of a lake than a river environment. These pits provide optimal habitat for predatory species, and their conditions may lead to smolt mortality through physiological stress from elevated water temperature and depressed dissolved oxygen levels. Lack of flow velocity can cause smolt disorientation.

- ***Reservoir releases made in autumn to evacuate the flood storage space can cause high flows for short periods. Salmon spawning during these periods could lead to the loss of redds which may be stranded when flows are cut back. Additional information is needed to minimize this problem and to determine if flows can be adjusted to benefit spawning salmon.***

Fall-run chinook salmon generally begin to migrate into the lower Stanislaus in late September and continue through mid-December. Spawning begins in mid-October and continues through early January. This part of the life stage coincides with the annual evacuation of the flood storage space.

Fluctuation flows can be disruptive to salmon reproduction at several stages. Female chinook salmon with preferences for velocity, depth, and substrate for building redds, can find that these characteristics change markedly in the river over the course of a day, and thus the selection of spawning sites is complicated. Females committed to constructing a redd on suitable substrate can be thwarted for parts of a day by either dewatering or very high velocities. Once spawning occurs, embryos and alevins in the gravel could be damaged by dewatering or by gravel scour if peak flows are extremely high. Fry and early juveniles that feed in the river margins can be enticed into the riparian vegetation at high flows and left stranded by rapidly receding water levels.

FWS has made recommendations in the draft Anadromous Fish Restoration Program (AFRP) to reduce adverse effects of rapid flow fluctuations and subsequent dewatering of redds. See Appendix G.

High releases in autumn can also adversely impact the riparian vegetation of the river system. Many factors determine the recruitment, establishment, and survival of riparian tree species, some of which are closely tied to watershed hydrology. In floodplains downstream from dams, floods are reduced and high flows may not coincide with the period of seed dispersal. Wind dispersal of cottonwood and willow seeds coincides with the recession of spring floods that form seedbeds on newly deposited alluvium. Seeds are viable for only a few weeks and are poor competitors with other plant species.